

Ohio Agricultural Experiment Station.

BULLETIN 111.

WOOSTER, OHIO, DECEMBER, 1899.

INVESTIGATIONS OF PLANT DISEASES.

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BULLETIN

OF THE

Ohio Agricultural Experiment Station.

NUMBER 111.

DECEMBER, 1899.

INVESTIGATIONS OF PLANT DISEASES.

A SUMMARY OF THE WORK OF THE OHIO AGRICULTURAL EXPERIMENT STATION FROM 1891 TO 1899, IN THE CONTROL OF DISEASES OF PLANTS.

BY A. D. SELBY.

INTRODUCTION.

BY THE DIRECTOR.

The following summary of the work of the Ohio Agricultural Experiment Station in the control of fungous diseases of plants has been prepared at the request of a committee of the Association of American Agricultural Colleges and Experiment Stations, as a contribution to the exhibit to be made by the United States Department of Agriculture, at the Paris Exposition of 1900.

Investigations, having for their object the development of practicable methods for the control of plant diseases, were begun by this Station soon after its reorganization under the Hatch act, in 1888, and have since been steadily pursued. The period covered by these investigations has been marked in the United States, as well as elsewhere, by great strides in the science of vegetable pathology, a science which practically dates from the discovery, during the ninth decade of the nineteenth century, of the efficacy of salts of copper in controlling the parasitic fungi with which many higher plants are infested. Since this discovery was made in France it seems fitting that one of the contributions to the great exposition, with which that nation is celebrating the close of the century, should be a review of work accomplished and results attained in this field of investigation.

As the earlier publications of this Station on this subject are now out of print, it has seemed proper to give a somewhat detailed report

of the field experiments of 1891, especially as these experiments illustrate well the method of research which has been followed throughout, a method having special reference to the practical utilization, on a commercial scale, of the preventives and remedies indicated.

The more recent work has been more briefly outlined, since detailed publications are still accessible to those who may desire them; but it is hoped that even to those most familiar with the Station's work in this field the present publication may offer something of value, by presenting in a single perspective the various investigations in this very effective line of public service.

Yet another reason for offering this review at the present date may be found in the years to come. As we look back over what has been accomplished during the past decade in the demonstration of the value and practical use of fungicides, we may properly reflect that this phase of the study of parasitism has probably reached its highest point. Already there are indications that the diseases not controlled by the use of fungicides are to claim in the future a large share of attention from the vegetable pathologist. The possible roles of enzymes, or soluble ferments, in the plant itself, and of soil-infesting fungi, beyond the reach of fungicides, are being studied, and there would seem to be no more opportune time of presenting this review of what has been accomplished than just at the moment when we are beginning to look forward towards new fields of research. The demonstration of the attainments of the past and their great practical value will be the surest basis for predicting the results and value of future work along similar lines.

GENERAL PLAN AND LINES OF WORK.

Several distinct aims have always been in view; yet these admit of condensation into a single statement, namely, the profitable control of the fungous diseases of the plants cultivated in the state. To attain this end several objects have seemed to require separate recognition:—

1. To obtain a knowledge of the parasites in question.
2. To discover the best fungicides for the end sought.
3. To determine the time of most efficient application, also the number of applications required.
4. To conduct the experiments on a commercial scale.
5. To coöperate, when possible, with growers centrally located for the matter studied.
6. To first serve interests in urgent need and of largest importance.

In following out the plans just stated many and varied investigations were made at the Station itself and upon its own grounds; in several instances this work was entirely done on these grounds at Columbus and latterly at Wooster. Coöperation became necessary at times, and throughout it has been steadily pursued as a policy, since local demonstration

of the value of results within the boundaries of a well developed industry, removes all questions arising from remoteness or lack of familiarity with conditions. Likewise work on a commercial scale lends itself to expression easily understood by the commercial operator. Throughout the work, and in all this resumé, it has been the policy to reject unprofitable methods, to avoid spray mixtures of excessive cost and to abandon any feature that would not succeed on a commercial scale or admit of wider application than mere demonstration of possibility.

APPLE SCAB.

In 1891 the officers of the Station carried out one of the pioneer investigations on this destructive apple disease. The results were published in illustrated form in December of that year (Bulletin No. 9, Vol. IV, December 1891). In that publication the Botanist, Miss F. Detmers, illustrated the effects of the apple scab fungus (*Fusicladium dendriticum* (Wall.) Fckl.) upon both fruit and foliage. A portion of these cuts are again reproduced. It was thus recognized at the outset that a leaf infesting fungus and a fruit infesting fungus was to be dealt with. In the same bulletin the Station Horticulturist, Professor W. J. Green, reported the results of spraying experiments.

SPRAYING TO PREVENT APPLE SCAB (1891).

It is proper to recall that at this time no really successful commercial experiments in orchard spraying for scab had been published. These were apparently the pioneer experiments on a commercial scale and the first, or among the first, successful ones with Bordeaux mixture.*

At this time (1890-91) Taft in Michigan and Goff in Wisconsin,

* See Fairchild, D. G. "Bordeaux Mixture as a Fungicide." Bulletin No. 6, Div. of Veg. Path. U. S. Dept. Agric. 1894.

Page 43 this author states:—"In 1891 Green carried on an excellent series of experiments in the treatment of the disease, which, from its size and the carefulness with which it was carried out, make it, so far as the writer's search has revealed, the most valuable contribution to the subject yet published. The experiments of Taft and Goff with other fungicides than Bordeaux mixture seem to have yielded results that will not bear a careful comparison with those obtained by the use of this latter mixture. It can quite safely be stated that in the treatment of apple scab this mixture has proved more efficacious than any other. From the extensive nature of Green's experiment and the evidence offered by the subsequent experiments of Goff, Lodeman, Munson and Garman, as well as from the testimony of many practical horticulturalists, it may safely be affirmed, that the treatment of apple scab is successful from an economic standpoint. The increased size of the fruit from the prevention of the fungus, which has been shown by Green to be considerable, as well as the production of fair fruit, make the increased market value of the crop many times greater than the expense of treatment."

In view of all this it is a matter of remark that Lodeman in "The Spraying of Plants," 1896, makes no reference to this publication, although a summary of work in 1891 is given, pp. 108-110.

as well as many European investigators, had experimented in the treatment of apple scab; some had tried but none had succeeded with Bordeaux mixture. The following report of experiments in spraying for apple scab is largely quoted from Prof. Green's original bulletin.

"The work in spraying apples was undertaken for the purpose of investigating the following points: (1) The compounds to use to prevent the apple scab. (2) The time to make the applications. (3) The compounds best adapted to be used with Paris green and London purple. (4) Profit in spraying on a commercial scale.

"In order to put the matter upon a commercial basis, as nearly as possible, an orchard of about thirty acres, two miles east of the Station, was selected and leased. One-third of this orchard was Newtown Pippin, a variety much subject to the scab, and the remainder was made up principally of Northern Spy, Rhode Island Greening, Baldwin, Jonathan, Westfield Seekno further, Smith's Cider, Bellflower and Roxbury Russet. Experiments in the same line were also carried on by the Station in Ottawa county, near Lake Erie, and in Lawrence county, on the Ohio river, by Nelson Cox, under direction of the Station. In each locality account of material and labor was kept, and notes taken when crops were harvested, in order to determine the cost of spraying and the profit when the operations are carried out on a commercial scale.

"About one thousand bushels were gathered from the trees included in the experiment near Columbus, and more than one hundred bushels were assorted and counted in note taking. In Lawrence and Ottawa counties the work was nearly as extensive, but the note taking was less elaborate.

COMPARISONS OF MIXTURES USED.

"The Newtown Pippin orchard was chosen for experiments with different mixtures, there being a sufficient number of trees to devote two rows of trees to each compound tested, and to leave five rows unsprayed. The following compounds were compared:

- (A) Ammoniacal Carbonate of Copper.
- (B) Modified Eau Celeste.
- (C) Dilute Bordeaux Mixture.
- (D) Precipitated Carbonate of Copper.
- (E) Ammonia-Copper Solution.

"Seven applications were made during the season as follows: April 8, May 7 and 26, June 13 and 19, July 16. The weather was very rainy during May and June, and the applications were made more frequently than would have been done otherwise.

"The following table shows the relative efficiency of the different compounds.

"In assorting, ten bushels were taken from each plot, in such a manner as to include about an equal quantity from each tree, of as near an



F. Detmers. del

FIGURE 1. The apple scab fungus on young fruit and leaves. This shows the early spring appearance (1891).



FIGURE 2. Apple scab fungus on older leaves (1891). This shows the appearance of scab-infested leaves in the later summer; such are liable to drop early. See page 102.

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average grade as possible. These were then separated into three grades, viz: first quality, free from scab; second quality, more or less scabby; third quality, very scabby or unmarketable.

TABLE I. RELATIVE EFFICIENCY OF SPRAYING COMPOUNDS.

Compound used.*	Per cent. of apples of first quality or free from scab.	Per cent. of apples of second quality or somewhat scabby.	Per cent. of apples of third quality or very scabby and unmarketable.
Ammoniacal Carbonate of Copper.....	5	72	23
Modified Eau Celeste.....	12	81	7
Dilute Bordeaux Mixture.....	15	74	11
Precipitated Carbonate of Copper.....	14	54	32
Ammonia-Copper Solution	1	50	49
Unsprayed		40	60

"It appears from the above exhibit that modified eau celeste, dilute Bordeaux mixture and precipitated carbonate of copper gave the best results, the latter showing the highest percent of third class, or very scabby apples. The results obtained with the three compounds are so nearly alike that the variation need not be regarded as important. Ammoniacal carbonate of copper and ammonia-copper solution fall below the others, the latter considerably so. This may be partly due to the fact that these

* The following are the directions followed for the preparations of mixtures in the above experiments. (See Bulletin Vol. IV, No. 9.)

"Ammoniacal Carbonate of Copper. — This is made by dissolving six ounces copper carbonate in two quarts of commercial aqua ammonia (more or less ammonia is required according to its strength), and diluting with fifty gallons of water. Although this did not prove to be so efficient as some other mixtures it is valuable to use late in the season on grapes, and wherever the Bordeaux would be objectionable, because of the coating it forms. Paris green or London purple should not be used in this mixture.

"Modified Eau Celeste. — Dissolve two pounds of copper sulfate in one gallon of hot water; also two and one-half pounds of carbonate of soda in the same quantity of hot water; when cool mix and add one quart of commercial aqua ammonia and dilute to thirty gallons. This compound is efficient and useful, but somewhat expensive and liable to injure the foliage of raspberries and pears. No doubt if diluted to fifty gallons it would be effective. Paris green or London purple should not be used with it.

"Dilute Bordeaux Mixture. — Dissolve four pounds of copper sulfate in two gallons of hot water; pour this into the tank or barrel and add sufficient water to cool it. Slake four pounds of quicklime, after which add water to make a paste or

compounds are more easily washed off by the rains than the three first mentioned. Possibly the ammoniacal carbonate of copper may be less effective than some of the other mixtures, but it still has a place, as will be shown in succeeding pages. The dilute Bordeaux mixture is preferable to the others for reasons that will be given further on.

"In order more fully to compare the different compounds it is necessary to consider the cost of each, nor is the cost of materials all that need be taken into account."

While in these experiments for 1891 the modified eau celeste gave slightly more favorable results than the dilute Bordeaux mixture, subsequent trials have been more favorable to the latter fungicide. The Bordeaux mixture is to be preferred by reason also of the possible combination of arsenites with it in the spraying.

"In spraying with the arsenites for the apple worm, Paris green or London purple may be used in connection with the Bordeaux mixture and the precipitated carbonate of copper, but since the latter is, of itself, liable to injure the foliage, it would hardly be advisable to add Paris green or London purple, and thus increase the danger. The combination of Paris green and Bordeaux mixture is not only harmless to the foliage, but saves the separate spraying for the apple worm. Table II gives the cost of materials and labor to spray one hundred trees for the season with each fungicide, also the cost when Paris green is added. With the Bordeaux mixture there is no extra cost in labor, but the price of the Paris green is added, as with the other compounds. The data for these estimates will be found under cost of spraying. The estimates are for four applications of fungicides and two of insecticides.

milk of lime; pour this into the vessel containing the copper sulfate solution, straining through a brass wire sieve as it is poured in. This operation with the lime should be repeated several times so as to dissolve as much as possible of it. Usually a quantity will remain undissolved, but the amount taken being more than is actually required it is not necessary to use it all. This mixture should be stirred and diluted to fifty gallons. If carefully made this mixture gives less trouble in clogging the nozzle than the strong Bordeaux mixture commonly advised. With the Vermorel nozzle it gives no trouble whatever. This mixture ranks high in efficiency, and Paris green or London purple can be used with it. It seems to have a wider range of usefulness than any other, and is confidently recommended.

"Precipitated Carbonate of Copper. — This is the same as modified eau celeste with ammonia left out. It is efficient and useful, but apt to injure foliage, although it may be used upon apple trees with safety.

"Ammonia-Copper Solution. — Dissolve one pound of carbonate of ammonia in six quarts of boiling water; add one-half pound of copper sulfate, and after reaction has ceased dilute to thirty gallons. This was not satisfactory as it injured the foliage except upon apple trees, nor was it efficient."

TABLE II. COST OF SPRAYING WITH DIFFERENT COMPOUNDS COMPARED.

Name of fungicide	Cost of material and labor to spray one hundred apple trees with the fungicide, one season	Cost of material and labor to spray one hundred apple trees with both fungicide and insecticide, one season
Ammoniacal Carbonate of Copper.....	\$17.30	\$22.55
Modified Eau Celeste.....	18.50	23.75
Dilute Bordeaux Mixture.....	14.10	15.10
Precipitated Carbonate of Copper.....	15.50	20.75
Ammonia-Copper Solution	13.70	18.95

"Had the Bordeaux mixture been used of the strength commonly advised, viz: Six pounds sulfate of copper to twenty-two gallons of water, the total cost would have been more than doubled, which would make it the most costly of all. It is not known whether the stronger mixture would be more effective than that used, but of the strength employed, as has been shown, it was as effective as any other compound. Its advantages over other fungicides are therefore apparent. It is not only the cheapest fungicide, but is the best to use in combination with the arsenites, because it prevents injury to the foliage and effects a saving in labor equivalent to two sprayings.

WHAT EFFECT DOES THE APPLE SCAB HAVE UPON THE FRUIT?

"Aside from the inferior appearance of scabby fruit, the effect of the scab is to retard the growth of both foliage and fruit, hence scabby apples are smaller than those free from scab. The difference in size between apples that are affected by scab and those that are free from it is not the same with all varieties, nor with any given variety in different localities. That the difference may often be considerable is shown by some comparisons that were made between scabby Newtown Pippins and those that were free from the disease. One bushel of that variety that were free from scab was found to contain 202 apples, while the same quantity of scabby apples contained 317. The average weight per apple was 4 and $2\frac{1}{2}$ ounces respectively. This comparison was between extremes, but those of the second class were, in size, far below those that were free from scab. It is no doubt true that scab may cause a diminution in size of fifty percent, but in most cases the loss is below that figure. In all cases scab hinders development but not always in proportion to the amount found on the

fruit. *With some varieties the scab does more damage to the leaves than to the fruit, the Ben Davis being a good example.* In Lawrence county, the past season, many trees of this variety *had lost nearly all their foliage because of scab, before the fruit ripened.* How much the development of the fruit was retarded cannot be estimated, but the loss was serious. Wherever scab is present at all, either upon fruit or leaves, the effect must be considerable in arresting the development of the fruit.

TO WHAT EXTENT DOES SPRAYING WITH FUNGICIDES PREVENT THE
APPLE SCAB?

"A comparison of the results obtained with several varieties will throw some light upon this question. Dilute Bordeaux mixture was used upon all throughout the season, except Rome Beauty, to which it was applied twice, followed by two sprayings with modified eau celeste.

TABLE III. EFFECT OF SPRAYING, AS SHOWN BY DIFFERENT VARIETIES.

Variety	Per cent. in first class; free from scab	Per cent. in second class; somewhat scabby	Per cent. in third class; very scabby and unmarketable
Benoni, sprayed	85	8	7
Benoni, not sprayed	4	58	38
Northern Spy, sprayed	56	43	1
Northern Spy, not sprayed	7	80	13
Newtown Pippin, sprayed	15	74	11
Newtown Pippin, not sprayed	00	40	60
Rome Beauty, sprayed	93	7	00
Rome Beauty, not sprayed	1	80	19

"Figs. 3-6 present the same facts to the eye in a more striking manner. The percentages were obtained by assorting ten bushels of sprayed and ten of unsprayed apples of each variety, into three grades, viz: Those free from scab, those somewhat scabby, and those that were so scabby as to render them unmarketable. Similar results were obtained with three other varieties not here shown. The figures were made from photographs, which were taken from average specimens of the different classes. The figures show the same percentages as those given in Table III. For instance, of the sprayed Northern Spy 56 in each 100 apples were free from scab, while in the unsprayed only 7 of the same class were found, and so on for the different classes of the several varieties. One hundred apples were photographed in each case, and the number in first, second and

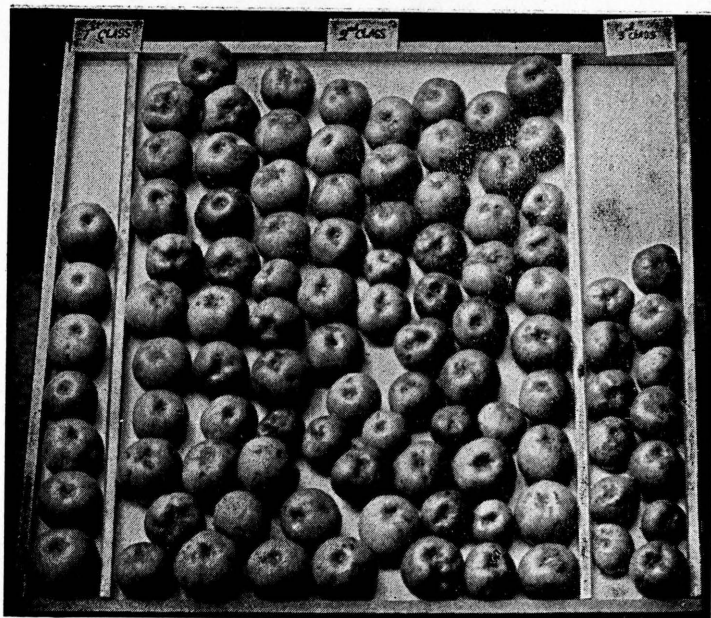


FIGURE 3. Northern Spy, sprayed; 1st class 56, 2nd class 43, 3rd class 1.
(1891.)

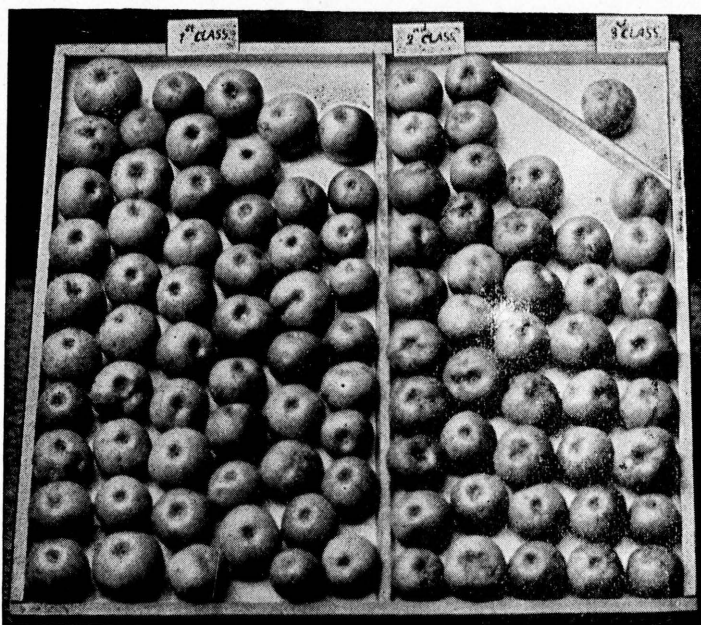


FIGURE 4. Northern Spy, not sprayed; 1st class 7, 2nd class 80, 3rd class 3.
(1891.)

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CORRECTION.

FIGURE 3. Northern Spy, not sprayed; 1st class 7, 2nd class 80, 3rd class 3.

FIGURE 4. Northern Spy, sprayed; 1st class 56, 2nd class 43, 3rd class 1.

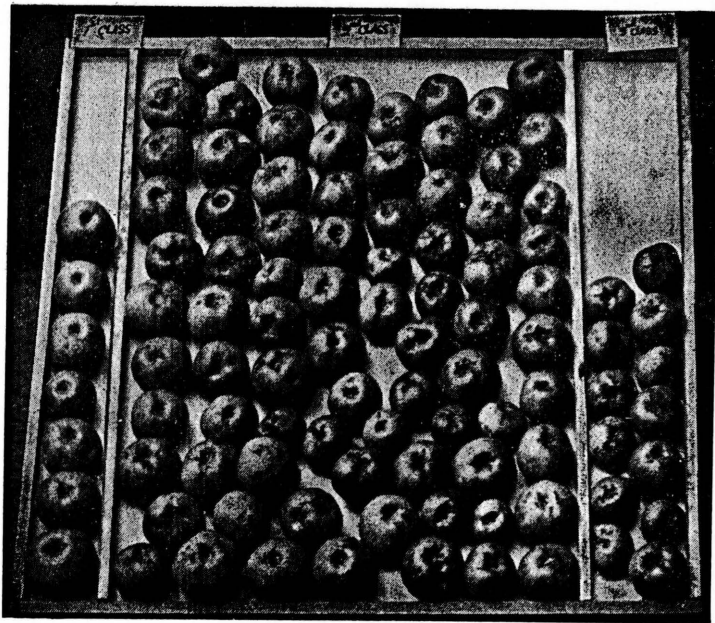


FIGURE 3. Northern Spy, sprayed; 1st class 56, 2nd class 43, 3rd class 1.
(1891.)

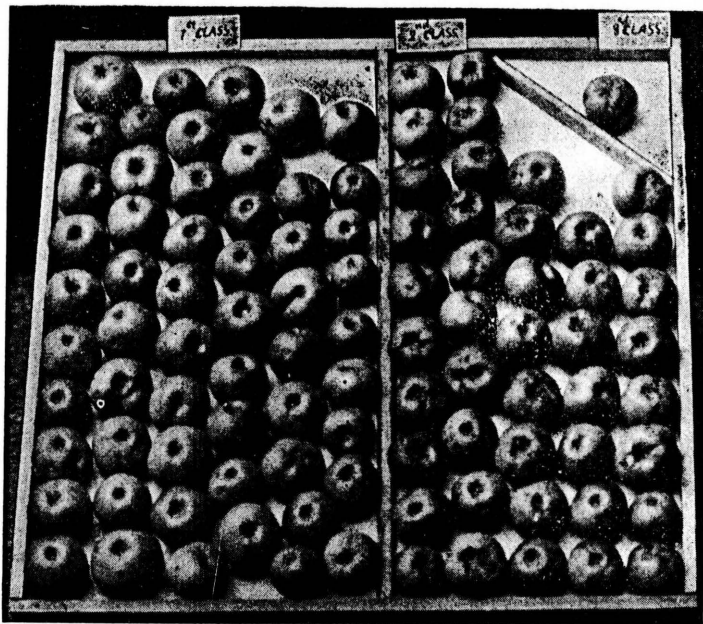


FIGURE 4. Northern Spy, not sprayed; 1st class 7, 2nd class 80, 3rd class 3.
(1891.)

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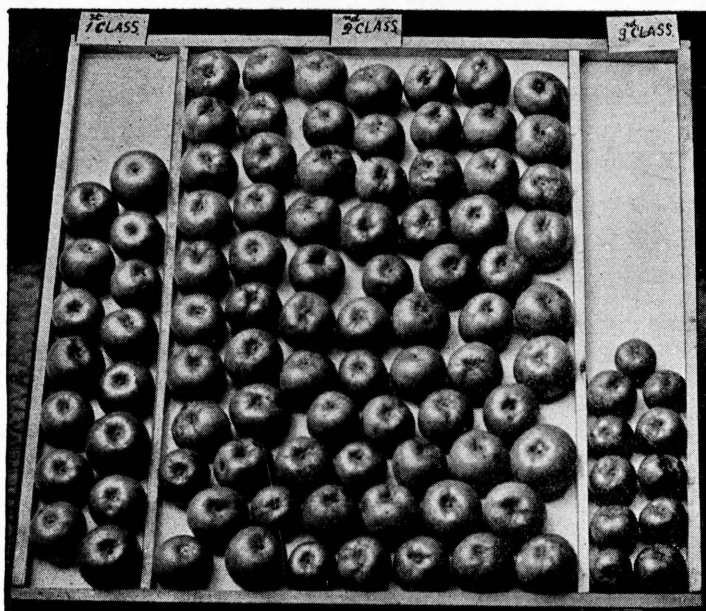


FIGURE 5. Newtown Pippin, sprayed; 1st class 15, 2nd class 74, 3rd class 11.
(1891.)

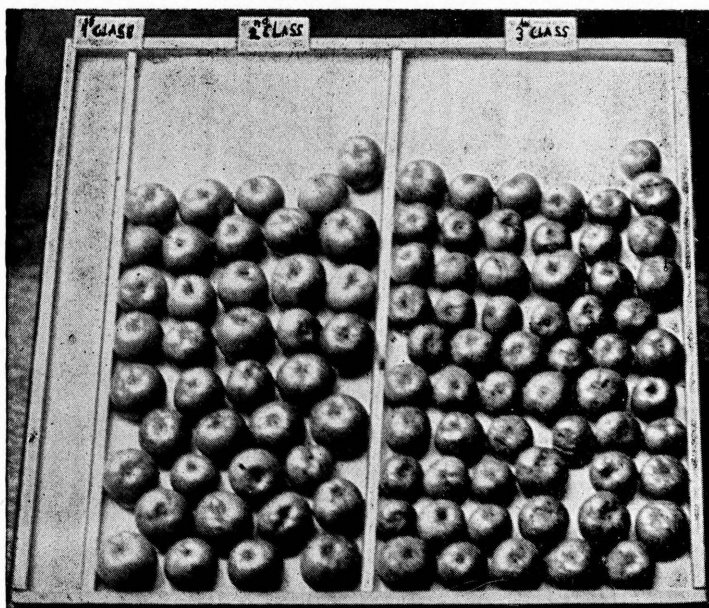


FIGURE 6. Newtown Pippin, not sprayed; 1st class 0, 2nd class 40, 3rd class 60.
(1891.)

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third classes shows the results obtained by spraying, also where no treatment was given.

"It appears from the above exhibits that the greater part of the apples of these varieties are subject to scab, and that spraying will not wholly prevent the disease. Better results could no doubt be obtained in a more favorable season, but at best the remedy is a partial one only. There is a gain with all varieties by spraying, but more with some than with others. If we make only two classes, viz.: scabby and not scabby, there was a gain of 81 percent in Benoni, 49 in Northern Spy, 15 in Newtown Pippin and 92 in Rome Beauty. This, however, does not fully represent the benefits as will appear further along, nor is it possible to state in percentages the exact extent to which scab is prevented by spraying; since there may be considerable variation in degree of scabiness and yet not change the classification materially. It would be unsafe to attempt to generalize any further than to say that spraying varieties that are subject to scab, with fungicides, prevents the scab in a great degree.

SIZE OF APPLES AS AFFECTED BY SPRAYING WITH FUNGICIDES.

"If spraying with fungicides were a perfect remedy the gain in size of apples would be much greater than it is possible to secure by means of remedies now known. The gain with Newtown Pippin, as shown on a preceding page, would be more than 50 percent if perfect results could be secured, but in practice the gain was only 10 percent. With Benoni a gain of 20 percent was obtained; with Northern Spy 23, and Rome Beauty 36. These percentages were obtained by the countings above referred to, and represent the actual gain in size of the sprayed over the unsprayed, taking the entire number of apples in each 10 bushels, first, second and third classes. To show the effect of the scab on the size, scabby apples were compared with those not affected, but to show the effect of spraying on the size, the comparison is made between sprayed and unsprayed, each taken as a whole.

"The effect seems to be quite unlike upon different varieties, and it would be hardly possible to draw conclusions from these figures as to the probable effect upon other varieties. The good effect upon the Rome Beauty was largely due to the beneficial action of the fungicide upon the foliage, as the sprayed trees retained their leaves much longer than the unsprayed. The increase in size by spraying any variety of apple with a fungicide will depend upon variable conditions, such as locality and season, but some increase may be expected upon most varieties in nearly all cases. Increase in size of the apples is a comparatively unimportant consideration in spraying, yet this alone would pay upon many varieties.

RATIO OF MARKETABLE APPLES AS AFFECTED BY SPRAYING WITH FUNGICIDES.

"In assorting into different grades, all that were marketable were put into the first and second classes, while those of the third class were fit only for cider or to feed stock and were classed as unmarketable.

TABLE IV. RATIO OF MARKETABLE APPLES AS AFFECTED BY SPRAYING.

Variety	Per cent. marketable	Per cent. unmarket- able
Benoni, sprayed	93	7
Benoni, not sprayed	62	38
Northern Spy, sprayed.....	99	1
Northern Spy, not sprayed.....	87	13
Newtown Pippin, sprayed.....	89	11
Newtown Pippin, not sprayed.....	40	60
Rome Beauty, sprayed.....	100	00
Rome Beauty, not sprayed.....	81	19

"This makes a very decided showing in favor of the sprayed apples. There was a gain of 31 percent with the Benoni; 12 with Northern Spy; 49 with the Newtown Pippin and 19 with the Rome Beauty. With some varieties the difference caused by spraying would be much less, in fact cases might occur where there would be no appreciable increase of marketable product of sprayed over unsprayed, but with most varieties spraying with fungicides would increase the number in the first class. It would also prevent the unsightly blackened and sooty appearance often seen upon varieties that are not otherwise affected, and it also has a tendency to heighten the color of red apples and to give a blush to the light skinned sorts. This may be due largely to the effect upon the foliage, but it was quite marked in some cases. Baldwins and Greenings that were operated upon in Ottawa county, where the scab was not seriously prevalent, were benefitted more by the fruit hanging on better upon sprayed than upon unsprayed trees, than in any other particular. This increased the marketable product upon sprayed trees, because there were fewer windfalls, but no notes were taken to show the amount of benefit. The same fact was noted in Lawrence county, but at Columbus the apples were picked too early to note the effect. It thus appears that the table does not fully show the gain in marketable product by spraying. The estimates may be considered as conservative for the varieties named.

MARKET VALUE AS AFFECTED BY SPRAYING WITH FUNGICIDES.

"Taking increase in size and increase in marketable product both into account, it is easy to see that the market value of sprayed apples would considerably exceed the market value of unsprayed. Improved appearance also is a factor that is not to be overlooked.

"In order to put the market value of sprayed and unsprayed apples to the test, equal quantities of each were put upon the market and sold for what they would bring. A sufficient quantity was taken in each case to make the test conclusive. The calculation is made on one hundred bushels, for convenience in illustration."

TABLE V. MARKET VALUE AS AFFECTED BY SPRAYING.

Variety	Value of 100 bushels in market	Increase in value of sprayed over unsprayed
Benoni, sprayed	\$56.70	\$28.10
Benoni, not sprayed.....	28.60	
Northern Spy, sprayed.....	\$65.95	24.05
Northern Spy, not sprayed.....	41.90	
Newtown Pippin, sprayed.....	\$48.91	26.11
Newtown Pippin, not sprayed.....	22.80	
Rome Beauty, sprayed.....	\$73.44	33.74
Rome Beauty, not sprayed.....	39.70	

"It appears from the above exhibit that spraying greatly increased the market value of all the varieties named, and in the case of Newtown Pippin the value was more than doubled. The difference was also quite marked with Bellflower and Smith's Cider, but less so with Baldwin and Greening. Complete notes were not taken on these, hence they are not included in the table. Since the cost of spraying did not exceed two cents per bushel, and the average increase in value was twenty-eight cents, it will be seen that the operation was profitable. The sprayed apples sold at a higher price than the unsprayed, and yet went off more readily and quickly. This difference alone would, in some cases, pay for the spraying, in time saved in marketing. Not only does spraying save time in marketing, but as has been shown in previous pages, it makes marketable that which could not be sold otherwise. Had the varieties named been stored, and not put upon the market until late winter or spring, the difference in value of 100 bushels, sprayed and unsprayed, would have been still greater. An experiment to test the keeping qualities of sprayed and unsprayed, not yet completed, shows that the sprayed are keeping much the better. This item would have a decided effect on the balance in many cases. On the whole, the result as it stands is satisfactory. The work was undertaken and carried out on a commercial scale in order to determine what profit there is in spraying. Table V gives a very clear and forcible answer for the varieties named and for one season. More or less variation may be expected for other varieties in different localities, but those who are in the best position to know feel sure that spraying with insecticides and fungicides is a necessity in successful orcharding.

COST OF SPRAYING.

"The cost of spraying will, of course, vary with the facilities for work and with the skill of the operators. Copper sulfate can be had for

about six cents per pound by the barrel, but the price is somewhat higher in smaller quantities. To spray large trees thoroughly nearly one pound per tree is required for four sprayings, or for the season. For trees fifteen to twenty feet in height it is safe to estimate three-fourths of a pound per tree. Three men can spray 200 to 300 such trees in one day. This brings the total cost, including two applications of Paris green, below fifteen cents per tree for large trees, during the season, and less for smaller trees according to size. This estimate is for dilute Bordeaux mixture and Paris green."

WHEN TO SPRAY.

"It should be borne in mind that spraying with fungicides is preventive rather than remedial, hence the first application should be made early in the season. Some results obtained the past season indicate that early spraying is the key to success, and experimenters generally have urged this point. The first application should be made before, or about the time that the leaves open. The Bordeaux mixture alone may be used at this time, particularly if the work is done before the leaves open, but if delayed until a few days after the buds start, and canker worms are known to be present, it is well to add Paris green or London purple."

"The second spraying should be made immediately after the blossoms fall. This application should not be delayed several days, and it is well to commence as soon as the greater share of the blossoms have fallen. There is no necessity of commencing before this time, nor is it advisable. For this application the combination of fungicide and insecticide should be used, i. e. dilute Bordeaux mixture and Paris green or London purple, the insecticide being to destroy the apple worm.

"The third application may be made a week or ten days from the time of the second, and with the same materials. If either ammoniacal copper-carbonate or modified eau celeste is used the Paris green or London purple must be applied alone, since the ammonia present in these solutions renders the arsenites soluble, which endangers the foliage.

"The fourth and last application for the season should be made in about two weeks from the time of the third, and dilute Bordeaux mixture alone used. For early ripening varieties the fourth application may be omitted, or the time between applications lessened. This is to avoid leaving a coating of the mixture on the fruit when ripe.

"In some of our work the past season seven applications were made, but in a part only four were given. The success with the latter number was so good that it seems safe to advise that number of sprayings. It is important, however, to observe closely the time advised for the first and second applications, since success depends more upon these than the subsequent ones. If the weather is rainy during the spraying season it is better to keep the work going than to wait for dry weather. Of course it would be impracticable to spray during a rain-storm, nor would it be best to spray immediately before, but if the mixture has two or three hours

in which to dry before a rain it will adhere so closely that but little of it will be washed off. Much of it will remain for weeks even during very rainy weather. One application made before a storm was repeated the past season immediately after a heavy rain, but with the mixture advised this is hardly necessary, except for a few trees that were sprayed just before the rain came. It is better to spray at the proper time than to wait for dry weather."

CO-OPERATIVE EXPERIMENTS

"Following is the report of an experiment in spraying for apple scab made in coöperation with the Station in Lawrence county, Ohio:

SIR:—I have the honor to submit herewith my report of experiments for the prevention of apple scab, made in Nelson Cox's orchard located five miles from the Ohio river, north of Huntington, W. Va., in Lawrence county, Ohio.

U. T. COX, *Ensee, Ohio.*

W. J. GREEN, *Horticulturist, Ohio Experiment Station.*

The variety of apples experimented on was the Rome Beauty. They were sprayed the first time just after the bloom fell. I sprayed the first two times with the dilute Bordeaux mixture, adding London purple as an insecticide. The last two sprayings were done with modified eau celeste. The Bordeaux mixture is preferable for all four sprayings. The Vermorel nozzle was used.

I sprayed about 175 trees, small size, in one orchard, eastern slope, altitude about 800 feet above sea-level. I selected two trees of the same size as near as I could judge, in the same row and thirty feet apart. Sprayed May 5, 15, June 3 and 23, with frequent rains from June 10 to 22. Picked October 28, 1891. The results are tabulated below:

Treatment	Total yield in barrels	No. first class, free from scab spots	No. second class; slightly scabby	No. third class, very scabby
Unsprayed tree.....	Nearly 1	None	188	540
Sprayed tree.....	2	540	268	40

The leaves fell prematurely from the unsprayed tree, and the apples ceased to grow, so they were small and dark-colored, while the ones on the sprayed tree grew to good size and had a very bright red color.

I sprayed May 4, 14, 26, June 23, about 300 trees in another orchard. The two I selected stood on the north side of a hill on comparatively low ground, altitude about 750 feet above sea-level. The leaves fell prematurely from the unsprayed tree here also. Picked October 14. The unsprayed tree had just one barrel, the sprayed tree two and two-thirds barrels. I sent one barrel of each to the Station, so I had none of the unsprayed to compare with the remainder of the sprayed. There was just one peck of culls in the remaining one and two-thirds barrels, the others being first-class and nearly all free from scab spots. You know the result of the two barrels sent you. (See Table III.) There were 800 apples in the barrel of unsprayed and 590 of sprayed.

I sprayed one row May 5, 15, June 3, 24, on very high ground, nearly 1,000 feet above sea-level. The trees were old; the two selected stood in adjoining rows.

Leaves had not fallen from the unsprayed trees here. I did not count the apples from these two, I just sorted and barreled them. The result is below:

Treatment	First class	Culls
Unsprayed tree.....	1 $\frac{1}{2}$ barrels	1 barrel and 1 $\frac{1}{2}$ bushels
Sprayed tree	3 $\frac{1}{2}$ barrels	1 bushel

The unsprayed apples were rough to the touch in every case, while those sprayed were very smooth and bright. A person can shut his eyes and tell the difference by feeling. The finest apples were on the lowest limbs where they were sprayed; in the top where unsprayed. On low ground the unsprayed apples were very dark, and would be worth from twenty-five to fifty cents less per barrel than the sprayed; first class apples as to size in both cases. On high ground there would be but about twenty-five cents difference per barrel of the same class.

The cost of spraying young trees that would yield about a barrel each I find to be about six cents per tree for the season. Those that would yield two barrels each, about nine cents, and those that would yield four or five barrels, twelve to fifteen cents for the four sprayings. The cost of pump and fixtures is not included in the above.

The London purple used did not seem to be as effective on the codlin moth as I hoped for, yet I think it did a little good.

SUMMARY.

"1. The apple scab is a parasitic fungus, growing upon leaf and fruit, and flourishing in cool, moist weather.

"2. The effect of the scab is to cause a large proportion of the fruit to drop while quite small; to greatly disfigure and reduce the size and market value of that which matures, and to injure the vitality of the tree by causing a premature falling of the foliage.

"3. The growth of the scab fungus may be checked by spraying the trees at proper times during the spring with several of the copper compounds commonly used as fungicides.

"4. The most satisfactory compound thus far tested, regard being had to cost, convenience and effectiveness, is a dilute "Bordeaux mixture," containing four pounds copper sulfate, four pounds lime and fifty gallons of water.

"5. While it has not been found practicable to completely prevent the growth of scab in a single season, the experiments demonstrate that it is practicable to so reduce the injury from the fungus that the total value of the crop shall be very greatly increased, and that the value of this increase will far more than repay the necessary cost of using the fungicide.

"6. The effect of judicious spraying with fungicides is to check the dropping of immature fruit in the spring; to cause it to grow to larger size and more free from blemishes; to cause it to hang better to the tree while ripening; to cause it to take on higher color in ripening, and to improve its keeping quality. As measured by market value, spraying has added nearly 100 percent to the value of the crop at a cost of less than fifteen cents per tree."

PRACTICAL APPLICATION OF APPLE SPRAYING BY GROWERS. (1894).

Upon the publication of the Station's work in 1891, many apple growers proceeded to apply the successful remedy, Bordeaux mixture. Some very striking results obtained by Mr. F. P. Vergon of Delaware, Ohio, in 1894, merit reference here. The lesson of this particular work, as of much other spraying, is that it saved the crop of fruit. Four sprayings were made beginning with the opening of the buds and closing with a single application after the dropping of the blossoms. From a number of trees experimented upon, two average ones of the sprayed and unsprayed trees were selected, the fruit from each gathered and piled in adjacent heaps.

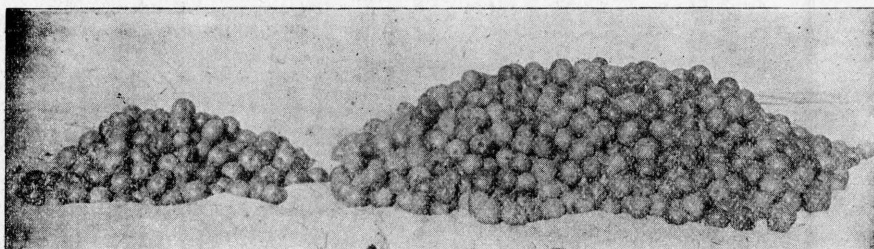


FIGURE 7. Spraying for apple scab in 1894, by Mr. F. P. Vergon, Delaware, Ohio. On the left $1\frac{1}{4}$ bushels unmarketable apples from one tree not sprayed; on the right $6\frac{1}{2}$ bushels of fine apples, all marketable, from one sprayed tree of same age and variety of fruit.

One and one-fourth bushels of scabby, unmarketable apples were obtained from the average unsprayed tree and six and one-half bushels of fine apples, all merchantable, were obtained from the average sprayed tree. Mr. Vergon practices spraying with Bordeaux mixture and arsenites, each year.

SPRAYING FOR APPLE SCAB IN 1897.

In 1897 Prof. Green again published the results of that season's spraying with Bordeaux mixture for apple scab. The paper was in his "Fruit Notes" for the State Horticultural Society and was printed in the Thirty-First Annual Report Ohio State Horticultural Society, pp. 11, 12. I quote this portion here:

"The efficacy of spraying has often been discussed in these meetings, but I cannot pass the present season's results by without reference in these notes.

"A general crop was not possible, because of the previous season's crop, but a general failure was not necessary.

"The cause of the apple crop failure where the trees bloomed last season must be laid mostly to the apple scab fungus, as it was more than ordinarily severe, and where proper treatment was given more or less of a crop was secured. In all of the Station's experiments no more strik-

ing results have ever been secured than those of last season, where the cost of treatment was repaid more than ten dollars to one.

"The orchard in question has been sprayed five years, except two rows which have never received treatment. Some trees of each variety are in the sprayed portion and some in the unsprayed.

"Taking the average yield, of the sprayed and unsprayed trees separately, we have the following results:

Northern Spy, sprayed, ave. per tree..	10.0 bu.	Unsprayed, ave. per tree..	6.5 bu.
Baldwin, " " " " ..	8.5 "	" " " " ..	3.25 "
Pearmain, " " " " ..	3.6 "	" " " " ..	0.75 "
Baltimore, " " " " ..	7.0 "	" " " " ..	3.5 "
Ohio Pippin, " " " " ..	6.6 "	" " " " ..	0.5 "
Wells, " " " " ..	5.3 "	" " " " ..	1.00 "
Grimes' Golden " " " " ..	6.25 "	" " " " ..	1.5 "

"The average per sprayed tree was 6.75 bushels, and of the unsprayed, 2.42. Fifty sprayed trees produced 4.33 bushels of apples more per tree than the unsprayed, which was secured at a cost of not more than 20 cents per tree. In the case of the Northern Spy and Baldwin the actual profit derived from the treatment was more than \$5.00 per tree.

"By unsprayed trees are meant those on which no Bordeaux mixture was used, but Paris green was applied to them for the apple worm. Some injury was done to the foliage in this manner. These trees suffered not only from the effect of the apple scab fungus but from the added injury of the Paris green. In thinning the fruit when small, in mid-summer, the poorest fruit was taken off. Both these factors make the benefit from the treatment from Bordeaux mixture appear greater than it really is, but there is sufficient evidence to show that the effect of the treatment was highly beneficial. A further factor, on the other side, in favor of the treatment, but which does not show in the above tabular statement, is that of improvement of keeping qualities of sprayed fruit. This is enough to offset the entire cost of treatment, and would make up for the injury done by Paris green.

"It is proper to state the fact that when the foliage of the tree is diseased it is much more susceptible to injury by Paris green or London purple than when healthy."

SPRAYING FOR APPLE SCAB IN 1899.

The results of apple scab treatment in 1899 are equally striking compared with those of previous seasons. The work has been continued at the Station while a number of apple growers give the same testimony as in the past, save that possibly losses from codlin moth have been rather greater than usual.

Mr. Nelson Cox reports by his son C. G. Cox a very fine showing from the use of arsenites and Bordeaux mixture. They estimate their increased product as sold for \$1000 more than it would have been worth without spraying, and at an outlay of about \$125 to \$150.

While there are still problems connected with the parasites of the apple orchard, the demonstration of the commercial value of spraying with Bordeaux mixture and arsenites appears now to be on a basis of general acceptance. In this later Ohio work, as in the earlier, the mixture has been used of the same strength as that given on page 95, namely 4 pounds copper sulfate and 4 pounds of lime to 50 gallons of water.

RASPBERRY ANTHRACNOSE.

In October, 1891, the Station Botanist and Horticulturist published, in Bulletin No. 6, Vol. IV., descriptions and treatment methods for raspberry diseases. In this publication it was shown that as a result of experiments in spraying with the dilute Bordeaux mixture the anthracnose fungus (*Gloeosporium venetum* Speg.) has been held in check. I quote from the bulletin —

"The treatment seems to have been very beneficial, and is referred to here in order that those interested may know what materials to use. The following, which is a dilute Bordeaux mixture, gave the best results:

Copper sulfate, 4 pounds.

Lime, 4 pounds.

Water, 50 gallons.

"To prepare the mixture the copper sulfate should be dissolved in two gallons of hot water, and the lime, which should be quick-lime, should be slaked slowly and water added sufficient to make a thin paste, or milk of lime. The copper sulfate solution is then to be poured into the lime, after which water sufficient to make 50 gallons is added. The quantity of lime recommended is more than is needed, but in practice it is found to be quite difficult to reduce all of it to the required consistency, and more or less remains in the bottom of the vessel in the shape of small lumps, which if left in would clog the nozzle; hence it is necessary to strain the lime paste before using, which occasions some loss, but leaves sufficient for the purpose.

"The first application should be made early in the spring before the leaves open, at which time the spraying should be very thoroughly done. The second application should be made soon after the young canes appear above ground, and the spray directed to them alone. The third application is to be made in about two weeks from the date of the second, taking the same precaution to spray the young canes only. The fourth and last application for the season should be made just previous to the time of blooming in the same manner as advised for the second and third sprayings. Raspberry leaves are very tender, and the mixture injures them slightly, but not enough to preclude its use, especially if some care is taken to keep it off the leaves of the bearing canes. The leaves on the young shoots of the current season's growth are not so easily harmed, hence no pains need be taken to keep it off them.

"Six ounces of carbonate of copper dissolved in three pints of ammonia, to which fifty gallons of water are added, has been used with nearly as good results as the above, and with even less harm to the foliage; but all things considered, the dilute Bordeaux mixture is preferred. The raspberry canes that have been treated with the above compounds are almost entirely free from the disease, and no doubt the crop will be much larger than upon the untreated plants. The prospect is so assuring that fruit

growers are advised to make a trial of the treatment for themselves. It should be remembered that the remedy is preventive, hence the first application is probably the most important of all."

While some others have not obtained equally satisfactory results in the use of Bordeaux mixture the outcome of the above described experiments in the following season was practically as anticipated. Professor Green has since repeated the experiments with like favorable results. The work of the Ohio Experiment Station demonstrates that the raspberry anthracnose is amenable to treatment with Bordeaux mixture when this fungicide is applied as described above.

SHOT-HOLE FUNGUS OF THE PLUM.

In the bulletin containing the results of apple scab prevention in 1891 (Vol. IV, No. 9) reference was made by the Horticulturist to the effects of spraying upon shot-hole fungus of the plum (*Cylindrosporium padi* Karst.) It was noted also that "one application of Bordeaux mixture (dilute) was very beneficial, and no doubt two or three are sufficient." Paris green is also recorded as having aggravated the trouble where applied alone. Other experimenters likewise reported similar effects, but definite recommendations were usually omitted. Fairchild* has recorded the variability of the trouble and its dependence upon weather conditions.

The writer has been afforded an excellent opportunity of pursuing the matter further. In 1896, the month of May was very warm and generally marked by a deficiency in rainfall of 1.5 inches.* The succeeding June, on the contrary, was very wet save in a few localities. Although the mean rainfall was scarcely 1 inch above the normal, precipitation occurred on 28 days of the month. July was even wetter than June, rain falling on 23 days of the month, the mean amount reaching 8.11 inches, or more than double the normal for this month. August rains were also slightly in excess. Under these conditions the fungus in question developed to an unusual extent. Nearly all plum orchards that had not been treated with fungicides suffered from the fungus; defoliation of trees was a general complaint. In many instances the loss of old leaves occurred early in August, followed by new leaves and blossoms. After such a record there came a great deal of injury from freezing in winter. The matter was presented before the Ohio State Horticultural Society in December, 1897.†

WINTER INJURY TO PLUM TREES AFTER SHOT-HOLE FUNGUS.

"In his report one year ago the writer pointed out the prevalence of shot-hole fungus and leaf-spot on plums and cherries, but did not anticipate at the time the serious winter consequences that befell the plum trees thus affected. In three and four year old orchards of Ottawa county,

* Bulletin Division of Veg. Path. U. S. Dept. Agric. No. 3, pp. 62 and 63; No. 6, pp. 39 and 40.

† See 31st Annual Report, Ohio State Hort. Soc. pp. 82-84.

fully one-half the trees were killed outright or were so severely frozen back as to be of little value. I have in mind an orchard near Elmore that suffered in this manner, but with unequal effects upon different varieties. In order of worst injury the sorts are: Beauty of Naples, Niagara, Bradshaw, Reine Claude, Geuii, Lombard, Shipper's Pride and Yellow Gage, the latter least injured of any. Nearly 50 per cent of the trees were practically destroyed. This orchard was attacked by the shot-hole fungus in 1896. Another large orchard near La Carne showed some striking results. The trees had been most of them defoliated about the first of August, 1896, and as reported to me, with specimens by the owner, had put forth new leaves and blossomed afterward. The leaves sent for examination were abundantly spotted with shot-hole fungus. The same trouble had been present to a limited extent in 1895. During that season the orchard was in corn and this fact was thought at the time to favor the spread of the shot-hole fungus. The fungus was neglected and greater injury followed.

"There are three portions of the orchard. In one the trees are 6 to 8 years planted, in another 3 years, and in another 1 year only from transplanting. Several of the 8 year old trees were destroyed through freezing of the trunks on south, southwest and east sides, and the separation of the bark. It is not with the variety, Coe's Golden Drop, an unusual injury in winter, but the severity is not common. Out of 10 trees of that sort, 5 or 6 were badly injured and 3 a total loss. There was a good deal of killing back on the large trees of other varieties. This was marked on 6 year Lombard and on other sorts as well. The younger trees suffered still worse. Among the 3 year trees practically all of two varieties, Bradshaw and Imperial Gage, were killed to the snow line. At the time of the severest cold last winter, quite a heavy snow lay upon the ground. The snow generously shielded the bases of the trees but all that part of the tree above it was badly frozen. Even where the trees put out new growth, the interior of the old wood seemed brown and dead. It is scarcely likely that any of the trees of these sorts will survive except by renewal from the base, which is possible with a part only.

"Among the 1 year trees, the Stanton variety was entirely destroyed, the interior of the trunks being brown; Reine Claude and Geuii were damaged. Killing back occurred in all the 3 year old sorts, including Bradshaw, Imperial Gage, Lombard, Niagara, Moore's Arctic, Shipper's Pride, Pond's Seedling, German Prune and Yellow Egg, named in order of injury. Those worst affected are named first. The Japanese sorts were not attacked by shot-hole fungus and were not winter killed.

EXPLANATION OF THE WINTER INJURY.

"The explanation lies in the late soft growth and general immature condition of the wood. As has been stated, the trees put out new foliage after the fungus had destroyed the first crop of leaves. All the growth made after August 1st remained unripened, and since all parts

participated in the growth, all were alike susceptible to freezing. Why the sorts like Coe's Golden Drop, Bradshaw and Imperial Gage should suffer more severely than other varieties, under the same general conditions, remains to be explained. Difference in habit of growth may account for it, or it may be a matter of varietal hardiness which may still be another name for the first suggestion. Throughout northern Ohio this severe injury occurred upon plums that had been defoliated by shot-hole fungus. It appears to be a new phase of the shot-hole fungus question and of such importance as to challenge study. The prevention lies in the avoidance of unripened conditions. This means under these conditions the prevention of the fungus by spraying, which is secured by about three applications as per the spray calendar. An additional spraying may sometimes be required. The spraying brought out, this year, an interesting fact. Older leaves on sprayed trees remained uninjured till the end of the season, while the leaves which were upon growth made after the last spraying (June 16) were taken off by the shot-hole fungus."

The statements made above as to spray treatment required is based upon the experiments of 1897, conducted in the orchard of Mr. J. W. Snider at La Carne, Ohio, the same in which severe injury occurred the previous winter. The orchard was divided for treatment into check lots and those to be treated one, two and three times. Applications of Bordeaux mixture were made on May 11, May 26 and June 16 to the respective portions.

In the summer of 1897, July only gave much rainy weather, so that the amount of injury from the shot-hole fungus was not so marked at any point. There was more of it on the trees receiving only the earlier applications of fungicide; yet, as noted above, the leaves on these late sprayed trees were saved just as far as covered with the fungicide. No more injury probably would have occurred, or but little more, under the conditions of the previous season; under normal conditions no injury at all. It is accordingly clear that effective fungicidal treatment for shot-hole fungus should begin when the leaves are half-grown, or slightly larger, and be continued at intervals of about three weeks—the last spraying may be made as late as the condition of the fruit will admit, yet will serve its purpose any time after June 15, in Ohio. The same fungus is likewise checked upon the cherry, but owing to the tender foliage, the Bordeaux mixture should be reduced to 1:25 strength, or two pounds each of copper sulfate and lime to 50 gallons of water. It is then effective and inflicts no injury to the leaves.

BROWN ROT OF THE PLUM.

The brown rot, (*Monilia fructigena* Pers.), is the most destructive disease of the commercial plum grower in our state and the most difficult to control. This latter character evidently exists because of the direct relation of the weather conditions to the development of the rot fungus. If these conditions be bright and fair, or interspersed by occasional showers and clearing weather to follow, unless temperatures be excessive the losses from rot may yet remain inconsiderable; but should consecutive rainy days and high temperatures prevail together, as is so liable to occur during the plum-ripening period or that immediately preceding, losses from rot are an almost certain result. Experiments, therefore, will yield diverse results under the varying temperature and precipitation. One will be likely to meet quite as many negative as positive results. Such has been the outcome at this Station.

EXPERIMENTS FOR THE CONTROL OF PLUM ROT.

The writer conducted a carefully planned series of experiments in 1897 in combination with Mr. B. H. Elwell, Gypsum, O. The details of the experiment are of little moment since the check, unsprayed trees gave little rotten fruit and no difference between the treated and untreated trees could be discovered. It may be stated that all mummy fruits from the previous year's decay were removed and destroyed in all cases; this is a first requisite for the handling of rot and may be supplemented by the spraying and care for rotted fruits, as is shown by some work by Professor Green at this Station in 1898.*

"If we may judge from the past, plum as well as peach culture must fall into the hands of specialists. Last season's results with the plum rot were discouraging. The wet season favored the disease, but it can hardly be denied that as the number of trees increase, so do their enemies. The plum rot now seems to be the greatest obstacle to plum culture, but the results at the Station last season indicate that it may be held in check in a great measure. Our orchard is not well calculated to give the best results in such experiments, as only two-thirds of the trees are sprayed, leaving one-third to breed disease and contaminate the others. It is our custom to make about four applications of Bordeaux mixture, while one tree [in every group of three] is left unsprayed. All the trees are jarred for curculio. Incidentally it may be said that those trees which were both sprayed and jarred had a heavier crop of plums when our countings were begun. It seems to be easier to control the curculio by spraying and by jarring, both, than by either method alone. When we began picking rotten plums, July 13, many of the unsprayed trees had not enough left to make a good crop, but all of the sprayed trees had to be thinned more or less. The picking and counting of rotten plums

* 32nd An. Report, Ohio State Hort. Society, 1898, p. 28.

was continued at frequent intervals throughout the season. The first picking and counting showed that 36 percent of the unsprayed plums had already rotted, while of the sprayed only four percent were diseased. It was not supposed at first that it would be necessary to begin the removal of rotten plums at so early a date, and the work was not begun as early as advisable, hence the disease had secured such a foothold that it was carried to all the trees in the orchard by the wind. Two additional sprayings were given to some of the trees, and with beneficial results, the only objection to such a course being that the mixture remains on the plums when ripe. Had all the trees been sprayed from the beginning and the rotten plums removed from the date when we commenced, it seems safe to say that four applications of Bordeaux would have been sufficient to insure a crop. We got a fair crop from the sprayed trees, the loss from rot being 33 percent, while the loss on the unsprayed trees was 84 percent. When we consider that the effect was uniformly the same on different varieties these results are encouraging. Spraying for peach rot was successful in about the same degree, and for peach scab also."

DISEASES OF THE PEACH.

With the beginning of the writer's work at the Station in the fall of 1894, plans were laid for an investigation of peach diseases and experiments in spraying peach trees. He had been called in consultation in 1892 upon this matter; in 1893 the Station Horticulturist had begun a comprehensive spraying experiment upon newly set orchards of various kinds of trees at Wooster, and had continued this work in 1894. While at that time the more prominent peach diseases had received more or less study, usually disconnected, only a portion of these troubles had been published upon. Without entering into a chronological statement here, there appeared a promising field for that study, and it was undertaken. Discussions of certain results of these studies were presented before the Ohio State Horticultural Society in 1895 (29th Rept., pp. 74-76 and 80-83) and again in 1896 (30th Rept., pp. 87-90). The earlier papers dealt with the crown gall trouble and with the successful first prevention of brown or pustular spot (*Helminthosporium carpophilum* Lév.)

Publication in collected form was made in March 1898, in Bulletin No. 92, entitled "Preliminary Report upon Diseases of the Peach—Experiments in Spraying Peach Trees." In March 1899 this was supplemented by "Further Studies upon Spraying Peach Trees and upon Diseases of the Peach," in Bulletin No. 104. Both these bulletins are illustrated.

In the Preliminary Report upon Diseases of the Peach, after exhibiting the distribution of peach growing and the occasion for the study, five subdivisions are made of the diseases, namely, —

- I. Diseases due to mechanical agencies or unfavorable soil conditions.

- II. Injuries due to atmospheric conditions.
- III. Diseases referred to unknown or doubtful causes.
- IV. Fungous diseases of the peach.
- V. Diseases caused by animal organisms other than insects.

Under the first sub-division wounds and undrained soil are treated; under the second freezing, windstorms and hail; under the third (1) Yellows, (2) Rosette, (3) A twig disease or the Gum-flow, (4) Drop-sical swellings of branches, (5) Twig spots, (6) Crown gall; under the fourth (1) Rot, (2) Scab, (3) Brown or pustular spot, (4) Anthracnose, (5) Mildew, (6) Leaf curl, (7) Leaf spots, (8) Constriction disease of stem, (9) Twig-blight and Twig-spots, (10) Root-rot; and under V mention is made of injuries caused by nematodes and a reference to the attacks of borers and root lice.

Of these diseases, yellows, crown gall, rot and leaf curl are regarded as the most menacing in somewhat the order named. No addition was made to earlier observations on yellows by Dr. E. F. Smith.* Crown gall has given promise of developing into a very serious disease of the peach, especially for younger trees. It comes as excrescences upon the roots and crown of the tree and occasionally upon the stem at some distance above the earth-line; in the ordinary form it is often conspicuous upon nursery stock. The diseased trees usually die before they attain bearing age and the communicable nature is predicated. Peach trees set in a raspberry plantation affected with crown gall became attacked by the crown gall to the extent of 70.8 percent in two years. (B. 104, p. 211.) Prevention of infection was not secured by treatment with flowers of sulfur in the contact soil. Destruction of affected trees is recommended. The cause of crown gall remains in doubt. The rot, as with plums, which are attacked by the same fungus, has proved at times very destructive. The treatment consists in the destruction of rotted fruits and in the use of fungicides. No experiments have been conducted in this line, at least not carried to completion. Some were planned and the treatment applied but no positive results were secured. Leaf curl, fruit scab of peach and pustular spot were the subject of quite extended experiments to be now described.

EXPERIMENTS IN SPRAYING PEACH TREES.

These experiments were conducted by the Station Botanist in the orchard of Mr. William Miller, Gypsum, Ottawa county, with the owner's coöperation and upon a commercial scale from 1895 to 1897, inclusive. Similar treatment for leaf curl and scab was continued by Mr. Miller in 1898. Several varieties of peach that proved susceptible to the attacks of the leaf-curl fungus (*Exoascus deformans* B.), had been extensively planted in this portion of Ottawa county, where peaches are very largely grown. Among these varieties was the Elberta, which had been largely

* Bulletins No. 9, Div. Botany; No. 1, Div. Veg. Path.; No. 17, Farmers' Bulletin U. S. Dept. of Agric.

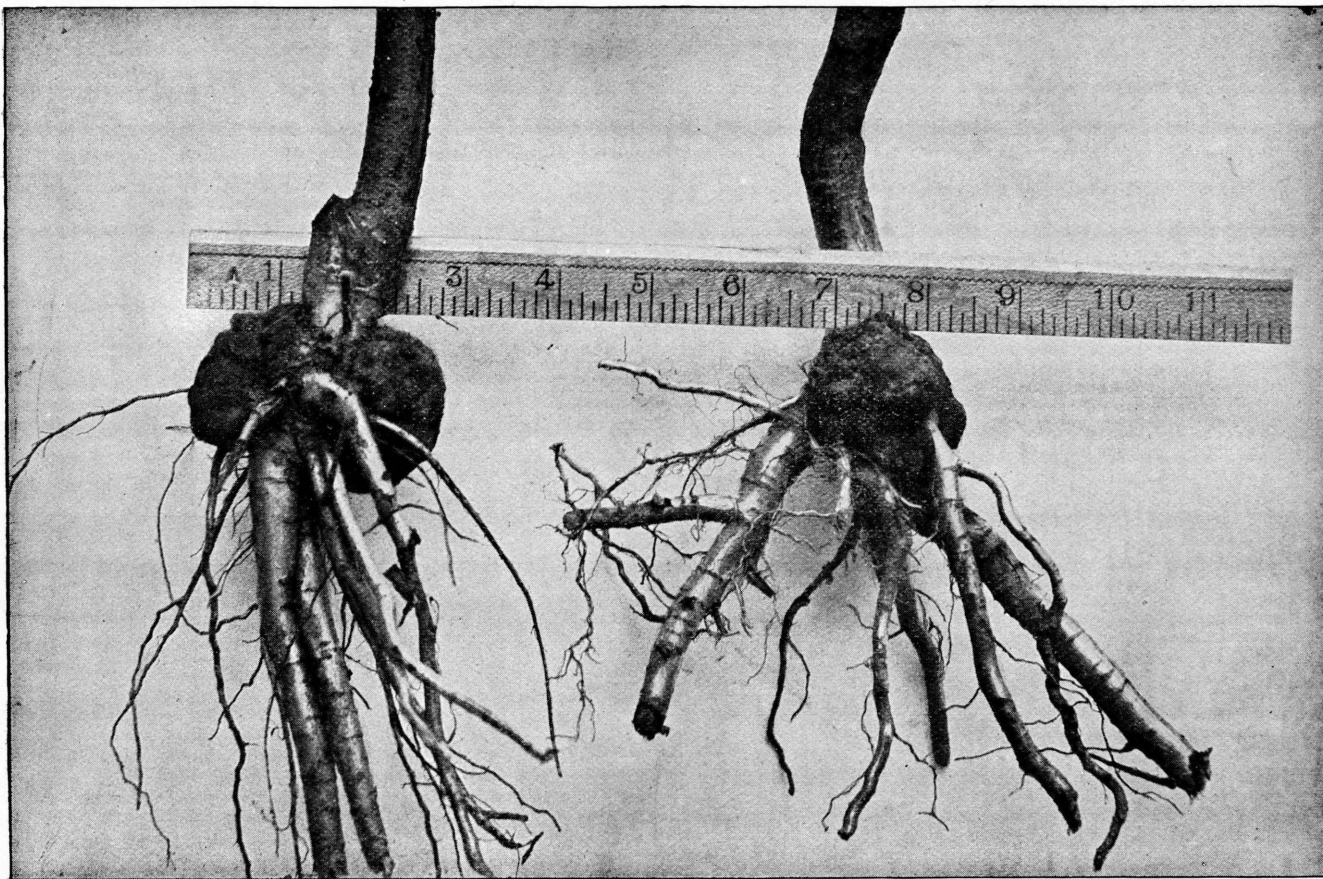


FIGURE 8. Crown gall of the peach. Showing cases of two nursery trees affected by the disease. They show the crown development of the galls. (From a photograph 1897.)

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planted in the newer orchards, but the attacks of the leaf-curl caused marked solicitude particularly in 1893, and to a less extent in 1894. This and other relatively susceptible varieties had suffered very severely. Mr. Miller estimated his loss on the Elberta variety in 1893 at 40 percent of the crop, while in 1894 his estimate was a loss of 5 percent. The writer's attention was called to this serious condition and it was suggested as a subject of importance to the peach grower. Some rather obscure troubles were likewise under investigation in the fall of 1894 when the writer assumed his duties at the Experiment Station. The Station Horticulturist had inaugurated an extended spraying experiment upon the newly planted orchards at Wooster. During the seasons of '93-'94, although these trees were young, some decided indications were obtained from the application of the dilute Bordeaux mixture, which was applied just before the opening of the blossoms and again just after these had dropped. Accordingly the chief reliance was placed upon Bordeaux mixture with alternative test of copper sulfate solution for the first application. In all cases the Bordeaux mixture was prepared by using equal weights of copper sulfate and unslaked lime; that is, an excess of lime was uniformly added. Since it was first necessary to determine the effect of the standard fungicide the original plan was followed through three years, except that the copper sulfate solution was not used in 1897. For the applications made after the blossoms had fallen, in all cases, a reduced strength of Bordeaux mixture, 2 pounds each of copper sulfate and unslaked lime and 50 gallons of water, or a 150 gallon formula was employed. Two orchards were under experimentation, known respectively as the South Orchard and North Orchard. The South Orchard occupies about 18 acres; while the North Orchard is almost as large though less of it was under experimentation. The orchard diagrams will be found in Bulletin 92. The following are the spraying schemes for these orchards, '95 to '97 inclusive:—

SOUTH ORCHARD SPRAYING SCHEME

Variety	No. of row	Treatment		
		In 1895	In 1896	In 1897
Elberta	1	1" lye solution.....	3" and 4" Bord. II.	Unsprayed.
"	2	"	"	"
"	3	"	"	"
"	4	"	"	3" & 4" Bord. II.
"	5	"	Unsprayed	2" & 4" Bord. II.
"	6	"	2" Bord. II.	2" Bord. II.
"	7	"	2", 3" and 4" Bord. II	Unsprayed.
"	8	2" & 3" Bord. II.	"	1" & 2" Bord. I.
"	9	Unsprayed	Unsprayed	"
"	10	1", 2" & 3" Bord. I, & II	1", 2", 3" & 4" Bord. I, & II.	Unsprayed. [& II
"	11	1", 2" & 3" Bord. I, & II	"	1" Bord. I.
"	12	1", 2" & 3" Bord. I, & II	1", 2", 3" & 4" Cop. Sul. & Bord. II ...	1" and 2" Bord. I. [& II.
"	13	1", 2" & 3" Cop. Sul. and Bord. I & II..	1", 2", 3" and 4" C. Sul. and Bord. II..	1", 2", 3" & 4" Bord. I, & II.
"	14	1", 2" & 3" Bord. I, & II	1", 2", 3" & 4" Bord. I, & II	1", 3" & 4" Bord. Unsprayed. I, & II
"	15	1", 2" & 3" C. Sul. & Bord. I & II.	"	"
"	16	Unsprayed	Unsprayed	"
Crawford ..	17	1" only, Bord. I.	"	"
"	18	1" & 2" Bord. I.	"	"
Salway	33	.....	" .....	"
"	34	.....	2", 3" and 4" Bord. II	"
"	35	.....	" .....	2" and 4" Bord. II
"	36	.....	Unsprayed	"
"	37	.....	" .....	Unsprayed.
		Dates	Dates	Dates
		1", April 25-26	1", April 18-20	1", April 23.
		2", May 10.	2", May 7.	2", May 5-6.
		3", May 21-22	3", May 22-23	3", May 11.
		.....	4", June 3-5	4", May 28.

NOTE. Bordeaux I refers to the standard strength of 4 pounds copper sulfate and 4 pounds lime to 50 gallons of water, or the 75-gallon formula — Bordeaux II, to half that strength, or the 150-gallon formula. 1", 2", 3", 4" are equivalent to 1st, 2nd, 3rd, 4th.

NORTH ORCHARD SPRAYING SCHEME

Variety	No. of row	Treatment		
		In 1895	In 1896	In 1897
Elberts, S. of Ditch	1	None	None	Unsprayed.
"	2	"	"	1", Bord. I. I& II.
"	3	"	"	1", 2", 3", 4", Bord.
"	4	"	"	2", 3", 4", Bord. II.
"	5	"	"	Unsprayed.
"	6	"	"	"
N. of Ditch.	1	1", Cop. Sul. Sol....	Unsprayed	"
"	2	"	"	"
"	3	"	"	"
"	4	"	3" and 4", Bord. II..	"
"	5	"	3" and 4", Bord. II..	"
"	6	"	Unsprayed	2" & 4", Bord. II.
"	7	"	2", 3" & 4", Bord. II	2" & 4", Bord. II.
"	8	1", 2", and 3", Cop. Sul. and Bord. II..	2", 3" & 4", Bord. II	Unsprayed.
"	9	1", 2", and 3", Cop. Sul. and Bord. II..	2", 3" & 4", Bord. II	1", Bord. I.
"	10	Unsprayed	Unsprayed	1'-2", Bord. I& II.
"	11	1", 2" & 3", Bord. I& II	.....	.....
"	12	2" and 3", Bord. II..	.....	.....
"	13	2", Bord. II..	.....	.....
"	14	Unsprayed	1" and 2", Bord. I & II	Unsprayed.
"	15	"	Unsprayed	"
Salway	1	"	"	"
"	2	"	"	" [& II.
"	3	"	"	1", 2", 4", Bord. I
"	4	1", 2", 3", 4", Bord. I, & II..	1", 2", 3", 4", Bord. I, & II	1", 2", 4", Bord. I [& II.
"	5	1", 3" and 4", Bord. I, & II..	1", 2", 3", 4", Bord. I, & II	Unsprayed.
"	6	Unsprayed	2", 3", & 4", Bord. II	"
"	7	"	2", 3", & 4", Bord. II	"
"	8	"	Unsprayed	"
"	9	"	2", 3" & 4", Bord. II	"
"	10	"	2", 3" & 4", Bord. II	"
"	11	" .....	.....	.....
		Dates	Dates	Dates
		1", April 25-26	1", April 18-20	1", April 23.
		2", May 10	2", May 7	2", May 5-6.
		3", May 21-22	3", May 22-23	3", May 11.
		4",	4", June 3-5	4", May 28.

From the diagrams just given it will be seen that certain rows received continuous treatment, while others were not thus sprayed. Continuous spraying had been begun on the young orchards at Wooster. The continuous treatment in these orchards was in the same line. It was hoped to discover the superiority, if any, of spraying year after year as against occasional or intermittent treatment. The results fully justify provision for such continuance of this spraying. Upon theoretical grounds it would appear possible to eliminate for a time certain parasitic fungi by the continuous use of fungicides. Moreover, from a practical point

of view it would be more economical to treat thoroughly year after year during the seasons of favorable weather conditions, and to attain the more favorable results, than to pursue less regular methods.

As before stated the rows in the South Orchard extend from north to south; accordingly rows at right angles to these were chosen for check purposes in Mr. Miller's spraying of that orchard in 1898. In the North Orchard the test for 1898 was made upon a section of the orchard left untreated in 1897. (Bulletin 104.)

EFFECTIVENESS OF THE SPRAYING FOR LEAF-CURL, (*Exoascus deformans* B.)

One chief object of the spray experiments was to check this fungus of the leaf curl. Attention is therefore directed to the results in this line.

In 1895 weather conditions were such as to develop a very slight amount of leaf curl. There was no observed difference between the sprayed and unsprayed trees in that year.

In 1896 there was a moderate development of leaf curl and the results of the spraying were quite evident. By careful estimates based upon laborious counts it was found that about 2.2 percent of the leaves on unsprayed trees of the Elberta variety in the North Orchard were attacked by the *Exoascus*. In the South Orchard the total amount was a little less on this variety. It was found that four sprayings reduced this amount of leaf curl to .2 percent of curled leaves (less in South Orchard); that is, the prevention of about 90 to 94 percent was attained in this way. (Bulletin 92, page 246.)

In 1897 conditions were favorable for the development of the leaf curl fungus. In this year's treatment certain rows in the orchard which had been sprayed two years were left unsprayed, while certain other rows that had been before unsprayed were this year treated with Bordeaux mixture. Careful counts were made in the orchards from June 12 to June 21, 1897. In Row 16 of the South Orchard, unsprayed in all years, there was about 88 percent of leaves affected with curl June 12 and about 50 percent had fallen June 18; while upon the adjacent Row 15, sprayed in previous years and unsprayed in 1897, there was 14.2 percent of curl affected leaves June 14, and about 8 percent of the leaves had fallen June 21. Upon Rows 13 and 14, sprayed throughout, there was but 7 to 8 percent of leaf curl with a loss of 15 to 20 percent of the leaves on June 21. Here the leaf fall was due to late spraying. On Row 9 of the same orchard, which had been untreated in previous years, the first and second sprayings in 1897 reduced the amount of curl from the 88 percent found upon Row 16 to 41 percent at about the same date of counting. In the North Orchard the results were very similar—in other words, *the spraying saved a good supply of foliage leaves for the peach trees*. There was no fruit in that year. There was conspicuous cumulative effect, as will be seen by comparing the full table in Bulletin 92, page 254. We may note here that Rows 8 and 9 are comparable, Row 8 being treated

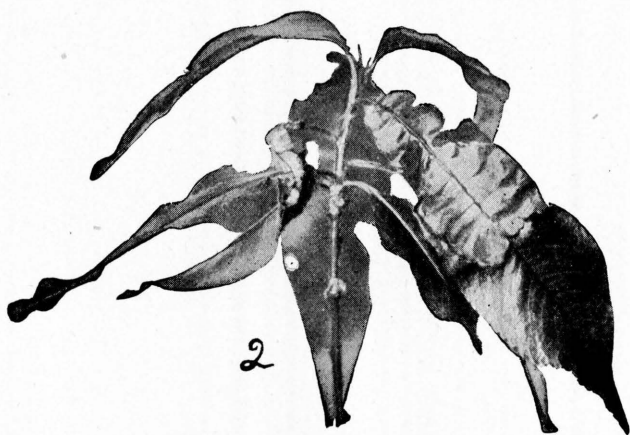


FIGURE 9. Leaf curl of peach caused by *Exoascus deformans* (B): 1 from Ithaca, N. Y., with leaves, petioles and a portion of the stem affected; 2 from Auburn, Ala.
(After Atkinson, Bulletin 73, Experiment Station of Cornell University.)

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FIGURE 10. Peach tree of Elberta variety 59 years old, sprayed. The tree was sprayed April 12, April 30 and May 17, 1898.
(From photograph June 11, 1898.)

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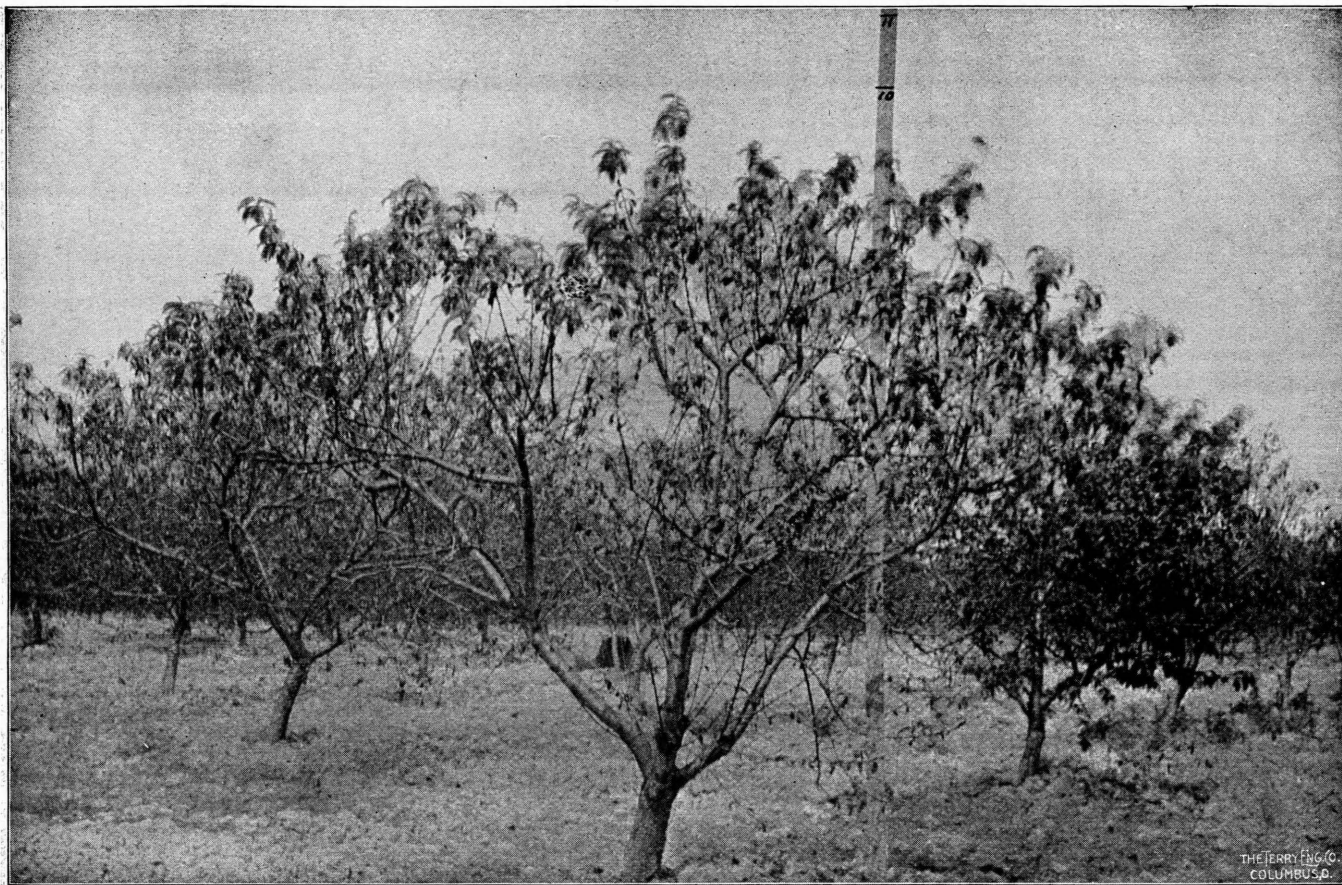


FIGURE 11. Peach tree of Elberta variety, 9 years old, not sprayed. From same orchard and same row as Fig. 10.

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in '96 while Row 9 was untreated. With the same treatment in 1897 the amount of curled leaves on Row 8 was 5.6 percent June 14, while on Row 9 it was 41 percent June 15. It does not appear from the next year's work that this cumulative effect upon leaf curl by continuous spraying may be expected under all circumstances. In 1898 in Mr. Miller's continuation of the spraying for leaf curl there was no apparent difference between the results upon the trees unsprayed in previous years and those which had been sprayed throughout. There was apparently a greater number of blossoms in both orchards upon the sprayed trees than upon the unsprayed trees. This season, '98, was one extremely favorable to the development of the leaf curl fungus, which may account for the nearly equal injury upon all of the trees not treated during the season. The illustrations, from photographs by the writer, will show the great difference in the trees which had been sprayed and those receiving no treatment, as exhibited June 11, 1898. Furthermore, the difference in the yield of fruit was very marked. The unsprayed trees yielded only an occasional peach while the sprayed trees yielded about 1.2 bushels per tree. The following statement is furnished by Mr. Miller and reprinted here from Bulletin 104.

SOME RESULTS OF SPRAYING IN THE NORTH ELBERTA ORCHARD OF WM. MILLER.

[GYPSUM, O.]

Number of trees unsprayed.....	165.
Number of trees sprayed (yield counted).....	119.
Number of bushels on unsprayed trees.....	11.
Number of bushels on sprayed trees.....	143.
Number of bushels per tree on unsprayed trees.....	0.066
Number of bushels per tree on sprayed trees.....	1.21
Number of bushels per tree gained by spraying.....	1.144
Total bushels lost by not spraying.....	186.45
Average price per bushel.....	\$1.50
Dollars, gross, lost by not spraying (165 trees).....	\$279.67

(See also Thirty-second Report, 1898, Ohio State Horticultural Society, page 13. The sprayed and unsprayed trees are adjacent.)

There was a difference in 1898 in the time of spraying; most of the sprayed trees were treated twice before blooming; namely, April 12 and April 30, and again after blossoming on May 17. These experiments covering four years show conclusively the value of Bordeaux mixture as a fungicide against *Exoascus deformans* on the peach. While for most of the work the earliest application was made just before the opening of the blossoms, or at a corresponding time, when the blossoms were killed by winter, the spraying of 1898 by Mr. Miller would suggest the equal efficiency of somewhat earlier treatment. From the series of experiments it does not seem wise to omit the spraying usually made just before the blossoms open. As compared with subsequent ones this is more than doubly effective.

PREVENTION OF PUSTULAR SPOT OF PEACH.

(Helminthosporium carpophilum Lév.)

The fruit in the orchards in which the experiments were made was attacked by this fungus (*Helminthosporium carpophilum*). It was found in 1895 that the later sprayings (particularly the third and fourth) had prevented the injury from this fungus to a very great extent. The same results were again obtained in 1896. The accompanying summary table will give a clear idea of the effectiveness of treatment given at different times (Bulletin 92, p. 249):—

TABLE SHOWING SUMMARY OF SPRAYING RESULTS ON PUSTULAR SPOT OF PEACH FRUIT IN 1896 — SOUTH ORCHARD.

No. row.	No. trees.	Treat-ments re-ceived	No. peaches	No. per tree	Yield bush.	No. spott'd peach's total	No. badly spotted	Per cent spotted	Per cent badly spotted	Age of trees
2	37	3 and 4..	6,525	179	43.33	271	11	4.15	.17	7 and 8 yrs.
8	35	2, 3 & 4.	6,057	170	37.25	62	1	1.02	.....	"
6	35	2	4,574	131	27.25	300	47	6.58	1.03	"
10	12	2 and 4..	1,427	119	9.	36	3	2.52	.02	"
5	38	Untreat.	6,938	182	43.75	1,130	212	16.28	3.05	"
9	33	"	7,539	228	47.25	1,186	223	15.73	2.96	"
16	33	"	5,609	167	34.	950	161	16.93	2.87	"
11	33	1, 2, 3, 4	5,528	167	32.25	61	.....	1.10	.....	"
14	31	1, 2, 3, 4	11,106	273	62.	92	2	.84	.....	"
12	26	1, 2, 3, 4	3,008	116	18.50	25	2	.83	.....	"

It will be observed that thorough treatment reduced the amount of spotted peaches to less than one percent, while on the average of the unsprayed trees the amount was above 16 percent. In comparison with the prevention of leaf curl, here it is later sprayings, rather than earlier, which are the more effective.

PREVENTION OF SCAB OR SPOT OF THE PEACH.

(Cladosporium carpophilum Thüm.)

These experiments were in particular designed to test the effectiveness of Bordeaux mixture in preventing the scab by continuous treatment. By two years' successive treatment of a susceptible variety, the Salway, in Mr. Miller's North Orchard, the percent of scabby peaches was reduced from about 70 percent to 39.27, and the proportion of those badly affected, which usually means those cracked open and consequently worthless, was

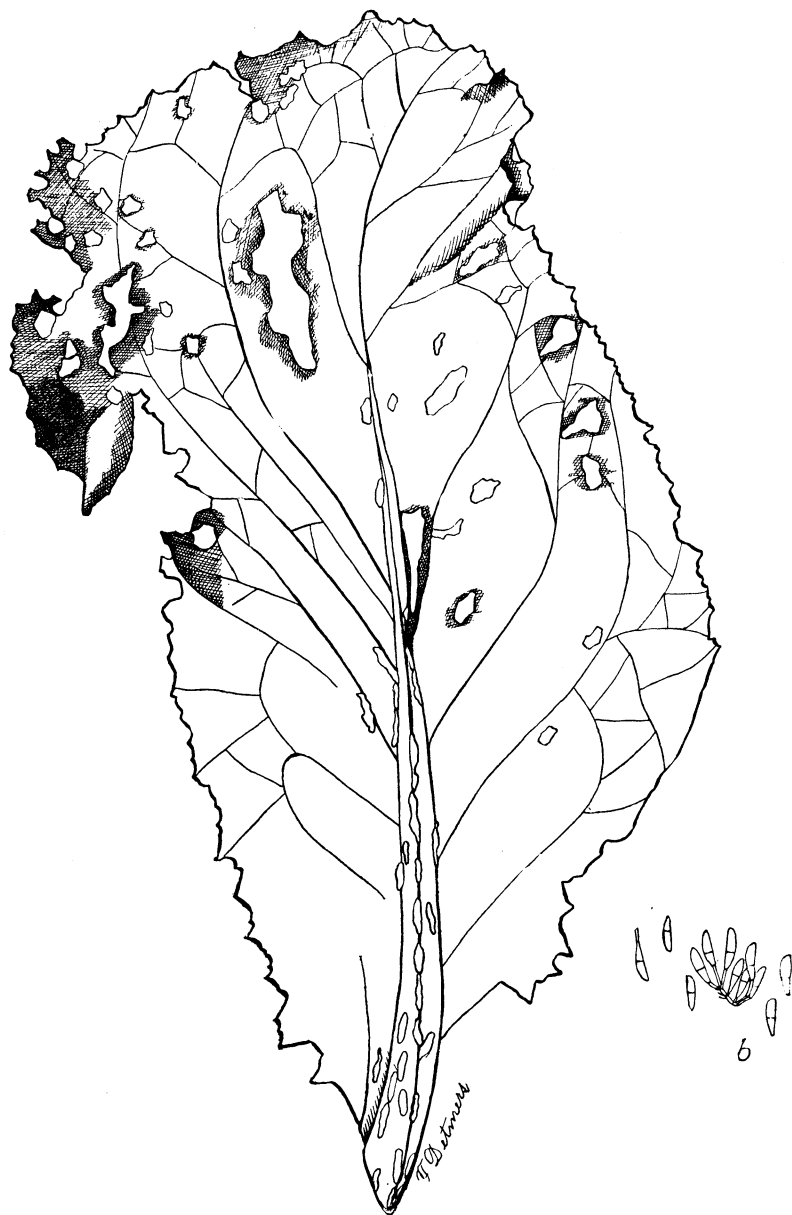


FIGURE 12. A Lettuce leaf attacked by anthracnose or leaf perforation disease. At *b* are shown the spores and spore-bearing parts of this new fungus, *Marsonia perforans* E & E, highly magnified. (1896.)

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reduced from about 30 percent to 3 percent. The results indicate very little benefit during the first year's spraying for this fungus. It is the continuous, in this instance the second year's, treatment which is effective.

DISEASES OF PLANTS IN THE FORCING HOUSE.

This Station, and I might add this Department of it, conducted investigations at an early date, to determine the prevalent diseases of the forcing house and the best methods for their control. (Bulletin 73, 1896.)

Among other things included in this bulletin are studies of the diseases of lettuce, diseases caused by nematodes, leaf mildews, diseases of cucurbits and tomato diseases. Under the first title the lettuce drop, or rot, referred to *Botrytis vulgaris* Fr., the downy mildew of the lettuce, (*Bremia Lactucae* Regel), the lettuce leaf perforation, or anthracnose (*Marsonia perforans* E. & E.), a new species therein described, are discussed and methods of control are pointed out. The last named trouble contributed by a lettuce grower at Troy, Ohio, was described and illustrated. It has since been discovered at other points in the United States. Perhaps the study of the diseases caused by nematodes, published in the bulletin named, has been productive of as much good as any similar one of like extent published by this Station. It was pointed out that the small excrescences upon the roots of the rose, the tomato, burdock, *Begonia metallica*, *Begonia rubra*, the cucumber, the violet, *Abutilon*, (cultivated) *Pasiflora* (cultivated) and the apple, are due to these parasitic, microscopic worms chiefly referred to *Heterodera*. Large excrescences with the eelworms in them were observed upon the stems and large roots of *Begonia rubra* and *Begonia olvia*. The destructive work of these minute worms upon the roots of forced cucumbers was also studied and illustrated. The effect upon roses was likewise carefully noted and experiments made in the treatment of affected rose plants. No successful remedy was discovered for plants once attacked by the *Heterodera*, and it was pointed out that previous preparation of the earth employed in the greenhouse benches must be relied upon for avoidance of these parasites. Winter handling and rehandling, to secure thorough freezing, was found effective in well rotted sod compost.

A successful result secured by Mr. Lodder, of Hamilton county, in steaming the earth used to grow cucumbers, was likewise published. It seems that this work, which Mr. Lodder was encouraged to undertake, was one of the early applications of the process of steaming soil to prevent the injuries from nematodes.

Among the diseases of cucurbits reference was made to the occurrence of *Plasmopara Cubensis* (B. & C.) upon forcing house plants near Cincinnati and in the garden of the writer at Wooster. This disease subsequently proved very destructive in the pickle and melon fields of the state. The cucumber spot, (*Cladosporium cucumerium* Ell. & Arth.) was noted as attacking the cucumber fruit in Mahoning county. What

was called at the time a new leaf blight of muskmelons and referred to *Alternaria* species, was illustrated and its injurious attacks described.

Under tomato diseases, aside from the common tomato leaf mold (*Cladosporium fulvum* Cke.) a new disease of forced tomatoes was described and illustrated. This disease shows similar symptoms to one described under the name of winter blight, by the Experiment Station of Cornell University (Cornell Bulletin No. 43), but is accompanied by other symptoms of the fruit, namely, dark spotting of the skin and occasionally further effects on the interior of the tomato fruit. The point rot of green tomatoes in the forcing house was referred to water conditions of soil. A second new arrival among tomato diseases, the tomato leaf blight (*Septoria Lycopersici* Speg.) attacking the leaves and stems of garden tomatoes, was also illustrated from Ohio material. Its successful prevention was attained by spraying with Bordeaux mixture, in 1897. (Bulletin No. 89.)

STUDIES OF THE DISEASES OF CUCURBITS AND TOMATOES.

Reference has already been made to the published results of work on the diseases of tomatoes. It remains to give some account of the investigations made with relation to the diseases of the cucumber and melon. In 1897 the general injury in the cucumber, pickle and melon fields of Ohio from the downy mildew (*Plasmopara Cubensis*) was very apparent. Pickle yields in this county, Wayne, became reduced to an amount that ceased to be profitable. (Bulletin 89.) The average for that year amounted to 71 bushels per acre in the county. The cucumber anthracnose (*Colletotrichum lagenarium* (Pass.) Hals.) was also noted and its injuries recorded. Extensive experiments were planned and carried out in 1898 to show what may be done by spraying. These coöperative experiments (with Dr. A. C. Knestrick of Creston, Ohio,) for prevention of downy mildew were very satisfactory. The increase in yield of the sprayed over the unsprayed areas amounted to 75 bushels per acre during a season in which the continuous rains made the early yield almost double that of the usual season. The relation of this earliness of the crop to the injury caused by downy mildew will be understood when we state that this fungus has never appeared earlier in the pickle fields of this section than August 10. It was first noted about August 18, 1897, August 13, 1898, September 9, 1899. So if the pickle crop is gathered by the middle of August the spreading of the disease may be expected to exert but little influence upon the total yield. (See Bulletin 105.)

The effectiveness of spraying for anthracnose of the cucumber was also brought out at Creston and in experiments made by Mr. C. P. Dyar, Marietta, Ohio, the latter upon early market cucumbers. The spraying of muskmelons upon a commercial basis for leaf blight (*Alternaria* species), downy mildew (*Plasmopara Cubensis*) and anthracnose (*Colletotrichum*) was also investigated and successful, as well as unsuccessful—

ful, experiments were recorded. (Bulletin 105.) With interest may be noted the large number of new hosts upon which *Plasmopara Cubensis* was collected in the pathological garden of the Experiment Station, Wooster, in 1898. (Bulletin 105, pages 219-20. See also Botanical Gazette, Jan. 1899, Vol. 27, page 67.)

THE PREVENTION OF GRAIN SMUTS.

Experiments in the prevention of the smuts of wheat and oats were begun upon oats at Wooster in 1895. (Bulletin 64.) These were continued in 1896, 1897 and 1898 upon oats and wheat. The whole series was conducted in coöperation with the Agriculturist of the Station. The most striking feature of the earlier work was the enormous amount of loose smut in the untreated oat plots amounting in one variety to 58.82 percent, and in several varieties reaching 30 percent and above. The most effective results were obtained by the hot water treatment, namely, that of immersing the seed oats for 15 minutes in water at a temperature of 133 degrees F. In a subsequent experiment it was found that equally good results were obtained by immersing the seed oats in hot water contained in a suitable open vessel, for 10 minutes at 133 degrees F., or 7 minutes at 136 degrees F., or 5 minutes at 140 degrees and 142 degrees F. with subsequent drying upon clean floor. (See Bulletin 97 by J. F. Hickman and A. D. Selby.) In the same bulletin it is shown that the loose smut of wheat (*Ustilago Tritici* Jensen) may be prevented by soaking the seed grain for four hours in cold water, then allowing it to stand four hours more in the wet sacks and afterwards immersing for 5 minutes in water at a temperature of 133 degrees F., as recommended by Swingle. (Year-book U. S. Department of Agriculture 1895, page 417.) By this method it is necessary to use one-half more seed to replace that injured by treatment.

Successful experiments in the treatment of stinking smut of wheat (*Tilletia foetens*) are recorded. About equally good results were obtained by immersing the seed for 10 minutes in hot water at a temperature of 133 degrees F. and by the action of copper sulfate solution, one pound to 5 gallons of water, for 20 minutes, with the subsequent liming and drying of the seed grain. In the same bulletin the Station Botanist has recorded the results of his study of the fungus of wheat scab, a disease more or less virulent in America and Europe, especially during seasons of excessive rainfall. This disease is referred to *Fusarium roseum* Lk. of which the ascigerous stage is identified as *Gibberella Saubinetii* (Mont.) Sacc. The same is illustrated.

CONCLUSION.

The investigations and experiments outlined in the foregoing pages have demonstrated the possibility of the successful and profitable control of the following fungous diseases of fruits:—

Apple scab (*Fusicladium dendriticum* (Wallr.) Fckl.)

Raspberry anthracnose (*Gloeosporium venetum* Speg.)

Shot-hole fungus of the plum (*Cylindrosporium padi* Karst.)

Peach leaf curl (*Exoascus deformans* (B.) Fckl.)

Pustular spot on the peach (*Helminthosporium carpophilum* Lév.)

Peach spot, or scab (*Cladosporium carpophilum* Thüm.)

Downy mildew of cucumber and muskmelon (*Plasmopara Cubensis* (B. & C.) Humph.)

Anthracnose of cucumber (*Colletotrichum lagenarium* (Pass.) Hals.)

Tomato leaf blight (*Septoria Lycopersici* Speg.)

Investigations have been conducted which made known and demonstrated remedies for point rot of green tomatoes, nematode diseases of the forcing house and fungous diseases of the same. A new disease of forcing house lettuce was published. In these demonstrations this Station has been sometimes a leader, sometimes a follower in a work in which many similar institutions were engaged, and while no claim is made to exclusive success and priority in all the lines of research indicated, it is hoped that they have contributed in some degree towards the extension of the boundaries of useful knowledge.